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RECENT BOOKS ON PHYSICS.

A Text-Book of Physics. By W. Watson, A.R.C.S., B.Sc. (London). Pp. xxii + 896. (London: Longmans, Green and Co., 1899.)

Heat for Advanced Students. By Edwin Edser, A.R.C.S., &c. Pp. viii + 470. (London: Macmillan and Co., Ltd., 1899.)

Text-Book of Experimental Physics. By Eugene Lommel. Translated from the German by G. W. Myers, of Urbana, Illinois. Pp. xxi + 664. (London: Kegan Paul, Trench, Trübner and Co., Ltd., 1899.)

IT is a pleasure to welcome a general text-book of physics by one of the younger generation of physicists, who has had wide experience in the modern methods of teaching and investigation. Since the general recognition of physics as an experimental science, these methods have changed so much that, although one could not but admire the skill and perseverance shown in re-editing the older text-books and writing them up to date, it was obvious that a great improvement could be effected by making a fresh departure.

In the arrangement of his book, Mr. Watson has adhered in the main to the order of exposition sanctioned by long experience, and has avoided the error, into which some recent writers have fallen, of attempting to revolutionise the basis of physical teaching. The author's guiding principle has been convenience of sequence from the point of view of simplicity and clearness of explanation, and he has thus succeeded in producing a work which the average student may be expected to follow with little or no previous acquaintance with the subject. This is a thoroughly practical basis, and will commend itself to students and teachers alike. As illustrations of this method, we may notice the introduction of a very useful chapter on wave-motion and water waves, with explanations of interference and other phenomena, before the discussion of Sound and Light. In a similar manner, the composition of simple harmonic motions is taken at an early stage as an illustration of periodic motion, instead of being reserved for the section on Sound. A great deal is gained in clearness, and saved in space, by taking difficulties of this kind in detail in their proper place.

Another feature of the book which will commend itself to a large class of students who are compelled to study physics without the aid of the higher mathematics is the elimination of purely mathematical difficulties. Some limitation of this kind is clearly essential in a general text-book, and the author appears to have exercised a nice discrimination in the selection of difficulties to be omitted. By curtailing the mathematics, he has also been enabled to devote more space to the explanation and illustration of purely physical questions, and to include many results of recent research which do not involve mathematical treatment. As an illustration of these points, we may quote the chapters on "Change of State," and on the "Ionisation Theory of Electrolysis," which subjects are treated from a modern standpoint.

In selecting the illustrations for the work, it has been assumed that the student will have access to a laboratory, and will supplement his reading with a practical course of experimental work. For this reason, no attempt has been made to supply elaborate figures of apparatus, or descriptions of details of construction and adjustment which the student can acquire much more effectually by laboratory practice. The illustrations are for the most part of a purely diagrammatic character, and are intended solely to elucidate the text, and not to take the place of the actual apparatus. There is no doubt that the general appearance of the book might be rendered more attractive, and its interest to the general reader, as distinguished from the practical student, would be increased by the insertion of a number of carefully printed and executed woodcuts of instruments and apparatus; but such illustrations belong properly to descriptive and technical treatises, and would be out of place in a text-book. Diagrammatic illustrations are really of much greater educational value when carefully designed, as they can be made to emphasise the essential points of the method or experiment, and are more easily remembered and reproduced than more elaborate pictures. The habitual use of such illustrations also tends to develop the diagrammatic faculty of thinking and working in diagrams, which is so extremely valuable to the experimentalist in designing apparatus or working out a method of research.

We are inclined to think that the utility of the book to the average student would be increased by the adoption of a more distinctive setting for the statement of laws and definitions, and that it would in many cases be desirable to emphasise more categorically the particular points in each law which are capable of definite experimental verification. The majority of students are too ready to accept a formula, and to regard as time wasted any attempt to prove it. They often acquire a fatal facility in dealing with symbols, which may perhaps suffice for examination purposes, but which does not correspond to a real understanding of the subject, and is of little educational value, and readily forgotten. Another addition, which would be of real value to the teacher as well as to the student, would be a carefully selected list of numerical examples, arranged to illustrate the various sections. It would be difficult to make a suitable collection, as nearly all extant text-books are lamentably deficient in this respect; but we are convinced that it would be of great use, and we may hope to see something of the kind in future editions.

In matters of detail a few errata may be noted by the careful reader, but this is natural, if not excusable in the first edition of a new book, and the majority have doubtless been already corrected. A purist might here and there find fault with the turn of an expression, or a specialist in some particular department might criticise some statement or explanation as being incomplete or misleading; but the book as a whole is remarkable for clearness and correctness of exposition, and must be regarded as a valuable and original contribution to our text-books of physics.

The object of Mr. Edser's book is to give a comprehensive account of the science of Heat, both in its theoretical and experimental aspects, so far as this can be done without the use of the calculus. The descriptions of the experiments to be performed by the students are

intended to be sufficient to enable them to secure accurate results. It is remarkable that this combination of the theoretical and the practical is not more often attempted. A book on any branch of experimental physics necessarily contains so much description of experimental work, that the additional instructions necessary to enable the student to carry out the experiments for himself would not add greatly to the length of the book. In a similar manner, a book intended simply for practical work in the laboratory generally and necessarily contains so much theory that it would not be a difficult matter to include all that the student would be likely to require in this respect.

The limitations which the author has imposed upon himself with regard to the use of the calculus apply chiefly to the section on thermodynamics. The method of expansion by the binomial theorem is used instead. The proofs are worked out from first principles, and are therefore generally longer than they would have been if the methods of the calculus had been assumed. But as a compensation they are much more instructive. The method of proof compels a close attention to each detail of the work, which is likely to result in a much clearer grasp of the physical meaning of the equations than the mechanical performance of mathematical rules for differentiation or integration. The student who has failed to follow the purely geometrical treatment of the same subjects in Maxwell's "Theory of Heat," will probably find these sections extremely helpful. They may be also strongly recommended to the mathematical student who does not desire to regard physics merely as a mathematical exercise.

In the selection of the experiments to be performed by the student, the author appears to have erred on the side of making them too simple, and of not exacting a sufficiently high standard of accuracy of the advanced student. He very rightly lays great stress on the importance of accurate thermometry, on which nearly all experiments depend. He might with advantage have given some details of the "variable zero method" of employing mercury thermometers, so ably expounded by Guillaume, which is now so generally used for accurate work. The method is laborious, but possesses undoubted advantages, and ought to be described in an advanced text-book, especially as it does not present any great theoretical difficulties. In determining the expansion of glass by means of the mercury weight thermometer (p. 68), the advanced student should be instructed to use the accurate equation $g=(m-m_g)(W-w)/W$, instead of the approximate equation $g=m-m_g$, which is given in nearly all the text-books. He should not be permitted to make an error of 1·6 per cent. in his calculation, when he may easily obtain observations correct to a tenth of 1 per cent. Similarly, in a text-book for advanced students, it would be more instructive if the author, in introducing a description of some of the old time-honoured experiments, had ventured to be a little more critical of their weak points, and to explain why they failed, or in what respect the deductions made from them were uncertain, or how they could be improved. It seems a pity at the present day, for instance, to repeat Tyndall's fairy tales about the absorption of heat by vapours without adding a large proportion of salt.

A special section is devoted to electrical thermometry, including an explanation of the principles of the methods employed, which is simple and at the same time fairly complete so far as it goes. We may note, however, in passing, that a platinum thermometer cannot in general be calibrated by reference to the absolute zero, as the resistance of the pure metal "tends to vanish" at a much higher temperature (*Phil. Mag.* Feb. 1899). Also that if a reasonably sensitive galvanometer is used, the heating effect of the current ought not to exceed a hundredth of a degree. The section contains an account of the thermocouple, thermopile, radio-micrometer and bolometer, which should be useful as well as interesting. In other subjects also, such as the liquefaction of gases, the book appears to be well up to date within the limits which the author has set himself. The whole arrangement is extremely clear and practical, and well adapted to meet the needs of students, who will find the most important points distinctly emphasised. There is a useful summary at the end of each chapter, and an excellent collection of examination questions. Considering its small size, the book contains a remarkable amount of information.

In the preface of Prof. Lommel's "Text-Book" the following explanations occur:—"The present text-book has grown out of the author's lectures, and is intended to develop the subject on an experimental basis in such a manner as to make the book easily accessible to beginners. But in order to meet the needs of higher schools and colleges, paragraphs in 'fine print' are interspersed, which contain the most important mathematical developments in terse and simple form. The author, as a general rule, has employed pure German words rather than technical expressions from foreign tongues, *e.g.* *wucht* instead of energy of motion or kinetic energy, and *spannung* instead of potential and difference of potential. The translator has not preserved the author's distinction between 'potential' and 'tension' (*spannung*), but has otherwise attempted only a faithful and worthy reproduction of the original."

These aims and endeavours on the part of the author and translator appear as a possible explanation of the introduction of several rather unfamiliar terms to English readers, such as "living force" for kinetic energy, "laws of shock" for impact, "stretch" for extension, "melting heat" for heat of fusion, "overmelted" for superfused, and similar phrases. The word "tension" certainly seems to be rather overworked, as it is used for the pressure of gases and vapours, as well as for electric potential, and even in one place for energy of position. On the other hand, we observe the apparently needless introduction of such words as "gyrotrope," "pachytrope," "rheotome," "rheometer" for the more familiar commutators, switches and galvanometers. The frequent use of oxygen for hydrogen, calcium for potassium, and coal for carbon are possibly simple *errata*.

The author has endeavoured to follow the historical order as being the most natural and interesting in the development of each part of the subject. The names and dates introduced in following this plan are often instructive and show a greater familiarity with English work than is common in Continental text-books. We may instance the dates, Boyle 1662, Mariotte 1679. The author neverthe-

less continues, in accordance with foreign usage, to quote the law Boyle discovered as "Mariotte's." He also gives a figure illustrating Cavendish's method of demonstrating the law of the inverse square in electrostatics, but the name of Cavendish is not mentioned, and the figure is labelled "Coulomb's Law."

It is probable that the historical motive is to be held responsible for the retention of many old experiments and figures of archaic apparatus. This is in many cases most desirable and instructive, provided always that the later developments are explained and illustrated so as to point the contrast. The experiments of Wheatstone (1834) on the "velocity of electricity" are of the highest interest and educational value, but it is not fair to leave the student with the conclusion, "Both electricities pass, then, simultaneously from the coatings of the jar, and meet midway between them. The velocity of propagation in a copper wire was found to be 430,000 km. By a different method Siemens (1876) found for the velocity in an iron wire 240,000 km." Again, it is certainly instructive to give a figure of the early type of German mirror galvanometer with a massive four-inch bar magnet inside a rectangular coil, but it is a mistake to ignore the essential improvements introduced by Thomson (Lord Kelvin), and to leave the student with the impression that the instrument figured is the type of a modern sensitive galvanometer. Similarly, in the section on the liquefaction of gases, we have an illustration of Pictet's historical apparatus (1877), and we are informed that "Hydrogen was liquefied at a pressure of 650 atmospheres and a temperature of $-140°$. On opening the tap an opaque stream of liquid of steel-blue colour escaped, at the same time the solidified hydrogen upon the floor produced a rattling sound as of falling shot." It is stated on the previous page that the critical temperature of hydrogen is $-174°$. No later experiments are mentioned. Such omissions as these can hardly be justified even in the most elementary work, and cannot fail to produce the impression that the book is not sufficiently up to date to satisfy the requirements of modern scientific education.

In endeavouring to explain a new term, it is often considered necessary in elementary text-books to put the idea into somewhat vague and general language, rather than in the form of a precise definition, because the more exact statement may fail to convey the idea intended. We are inclined to doubt the wisdom of this course, which appears to be carried too far by the author. The following are a few samples of the kind of statement to which we refer.

P. 24. "*Work.*—When a force acting on a mass sets it in motion, the force is said to do work, and the result of its action is called work." "In transforming forces into work, the question is not alone whether work is done, but also in what time it is accomplished. The work done in one second is called the 'effect' of the force."

P. 289. "*Equilibrium in Conductors.*—When a conductor has attained a condition of electrical equilibrium, the electrical forces, and accordingly also the electrical potential, are everywhere 0. This merely says that in a position of equilibrium, every point in and upon a conductor has the same potential."

P. 372. "*Wheatstone's Bridge.*—If the branches *amb* and *anb* of the current are connected by a cross wire *mn*, called a 'bridge,' two currents flow in opposite directions in the bridge. If these currents have equal strength they neutralise each other and no current passes through the bridge. . ."

P. 377.—"Edison's (1879) incandescent lamp depends upon the heating action of the current. A charged filament of hemp, or cotton, of high resistance (*e.g.* 140 ohms) and bent into the form of a horseshoe, is enclosed in an exhausted glass globe to protect the filament from burning, while a current of about 100 volts passing through it heats the filament to incandescence, giving it an intensity of approximately fifteen candles." (Nothing more is said on the subject of incandescent lamps.)

The paragraphs "in fine print" contain the majority of the formulæ, and are intended to meet the needs of higher schools and colleges. They appear, however, to be of too disconnected and occasional a character for the purpose. A good deal of small print, *e.g.* three pages on thunder and lightning, is of very elementary and purely descriptive character. On the other hand, some rather difficult points are discussed in the "coarse print," *e.g.* the "Second proposition of the Mechanical Theory of Heat. Entropy. Kinetic theory of gases." In discussing the Second Law of Thermodynamics and the Dissipation of Energy, no allusion is made to reversible cycles, and the information imparted is necessarily so incomplete that no application could be made of it. Mayer's calculation of the mechanical equivalent is given, but Joule's experimental verification of the assumption upon which it rests is entirely ignored. It may be questioned whether there is any profit in introducing such points if they cannot be adequately discussed. It is not very easy to follow the principle upon which the selection or omission of subjects for discussion is based. The book as a whole does not appear to be sufficiently definite and practical to be suited for class or examination work according to English standards. It is possible that it may be more suited to the methods in vogue in Germany or America.

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TWO NEW ZOOLOGICAL HANDBOOKS.

A Manual of Zoology. By the late Prof. T. J. Parker and Prof. W. A. Haswell. Pp. xv + 550. (London: Macmillan and Co., Ltd., 1899.)

An Elementary Course of Practical Zoology. By the late Prof. T. J. Parker and Prof. W. N. Parker. Pp. xii + 608, with 156 Illustrations. (London: Macmillan and Co., Ltd., 1900.)

PROFS. PARKER AND HASWELL have embarked upon a difficult and somewhat ambitious undertaking. To compress an account of practically the whole animal kingdom, with 300 illustrations, into a handbook of 550 pages, intended for beginners, is certainly no light task at the present day. Such manuals were quite possible so long as it was considered sufficient for a book of this kind to deal with the exteriors and the habits of animals, and to consist for the greater part of illustrations of monkeys, beasts and birds, while about one-fifth or less was taken up by reptiles, fishes and insects, with perhaps a figure or two of zoophytes or diatoms from Barbados earth. But